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13. ABSTRACT (Maximum 200 words) Establishment of the Texas Regional Institute for Environmental Studies as a multi-disciplinary, integrated, environmental research program has been accomplished. A set of discrete projects were undertaken by the Institute in order to demonstrate the efficacy of such an entity to successfully address a diversity of environmental problems. Within these projects, an array of environmental problems were addressed with the multi-disciplinary teams. Multi-disciplinary teams were formed through cooperation among academic departments, colleges, and institutions; government agencies, and private companies. Public/private partnerships were formed to address some of the problems. The problems addressed included: several projects for ecosystem-level natural resources management on military installations (including neighboring properties), development of activity based costing methodology identifying environmental costs, development of statistically based image analysis systems, development of new methods to reduce pollution from chemical synthesis operations, and development of a model air permitting strategy for industrial operations. Results from each of these projects, by their integrated nature, promote efficiency of operations, with concomitant potential for cost savings in future operations.				
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Cooperative Program Providing Public and Private Sectors with Information for Use on
Examination of Environmental Issues

Final Progress Report

Michael J. Warnock

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Statement of Problem Studied

The purpose of Army Research Office support under grant DAAH04-93-G-0505 was to provide support for testing an innovative approach to environmental issues. This innovative approach was undertaken by the Texas Regional Institute for Environmental Studies (TRIES) based at Sam Houston State University (SHSU). TRIES is a multi-disciplinary and multi-institutional program created to comprehensively examine environmental issues. The primary academic institution partner with SHSU is Stephen F. Austin State University (SFASU), with additional participation of lesser amounts by other academic and non-academic (private, corporate, and government) entities. The concept for TRIES grew from the fact that environmental issues are often dealt with on a site specific basis with a very narrow disciplinary focus. This situation often produces excellent short-term solutions for environmental problems, but in so doing, moves the problem to another location and/or delays a comprehensive solution for a later time. In general, such procedures lead to much more expensive solutions for the problem to eventually be completely solved. Results of such short-term solutions can be seen in our current exercise with the Superfund process. Many of these Superfund sites have their origins in waste disposal practices that were acceptable 20 or more years ago. From the viewpoint of the entities disposing of those materials and from a strict physical/chemical/engineering approach, disposal in pits and other similar sites was an acceptable means for handling their problem with regard to those materials. Unfortunately, the wider view was not taken that would incorporate how such materials behave biologically, growth over time of urban and suburban areas, human nature, and other factors that affect these sites. This short-term, narrowly focused solution has led to the current resurrection of the problem of dealing with the same materials again--the primary difference being that the materials may be partially altered in form, mixed with other materials, and may have migrated to less accessible sites, all these factors contributing to the greatly increased cost of dealing with the problem.

We have the advantage of hindsight to look back on the history of such events as the origin of Superfund sites, and we can therefore recognize some of the mistakes that were made. However, the same approaches are prevalent in our handling of environmental problems today. Most pollution problems are handled with short-term physical/chemical/engineering solutions, and it might be predicted that the future results will be similar to those producing the Superfund crisis we face today. This is not to say that the chemical or engineering approaches to environmental issues are any worse than other approaches. Parallels can be seen in biological, economic, and political approaches to handling environmental issues (endangered species, current vs. life cycle costing, regulatory mechanisms, etc.). In effect, these narrow approaches in any field tend to treat symptoms of environmental problems rather than solve the problems. True solutions to environmental problems need to incorporate input from all relevant sources in order to arrive at an understanding of the problem and a comprehensive long term solution for the problem. TRIES was developed to meet the need for comprehensive approaches to environmental issues.

TRIES provides a center of excellence for environmental research; long term monitoring and management of the environment; solutions for strategic environmental problems; and a credible source of the necessary knowledge, expertise, and training to accurately and successfully identify, examine, assess, and develop viable solutions for environmental problems. TRIES does this through a comprehensive, interdisciplinary approach supported by collaboration between academia, and the public and private sectors.

The grant from the Army Research Office allowed TRIES to test the feasibility of the comprehensive approach to environmental problems by experimenting with different combinations of multi-disciplinary collaborative teams to address a diversity of environmental issues in a variety of settings. Environmental needs faced by various installations of the U.S. Department of Defense (DoD) were the focus for most of the problems studied, and those installations provided a testbed in which to apply the comprehensive approach to the environmental issues. As might be expected, a comprehensive approach to environmental problems was new to personnel at the installations where work was undertaken. Most installation personnel were oriented toward obtaining solutions to environmental problems using their normal approaches, and many of the projects were made possible only by delivering the expected product or service to the installation while completing the comprehensive studies in parallel as an add-on to the product or service desired by the installation. The diversity of

problems studied, and the variety of regional and DoD command structures in which the work was completed, provided useful information as to how the comprehensive approach to environmental problems would work in other DoD and non-DoD settings. The research was accomplished through a series of projects, each of which is described below. The information contained in this report provides an overview of each project. Additional detailed information on the projects can be found in the publications, presentation abstracts, technical reports, theses, and other documents produced as a result of these projects. The success of the multi-disciplinary approach to most of these projects indicates that TRIES is a viable model that could be replicated in other regions to address environmental issues.

Summary of Most Important Results

Enhanced Image Assessment System--Mathematicians worked together with geographers, computer scientists, and biologists to develop a user friendly system incorporating statistical sampling and mathematical modeling techniques to enhance image assessment capabilities. The system is intended to use information from the image itself to designate boundaries and perform classifications of patterns within the image. Use of image-contained information reduces possibility of errors introduced by *a priori* classifications based on previously analyzed images. When appropriate, the system can incorporate a feature labeling assistance component that can be based on previously analyzed images. Theoretical basis and concept was developed, and limited field testing was conducted at Camp Navajo and Dugway Proving Ground with assistance of ARO funding. Results included in publications, reports, and presentations submitted to ARO. This program was transitioned to Strategic Environmental Research and Development Program (SERDP) funding through Oak Ridge National Laboratory (ORNL) for further development and combination of modules. The technology has possible future technology transfer and/or invention implications. DoD (through the Construction Engineering Research Laboratory) is exploring incorporation of the TRIES image assessment system into their Land Management System.

Comparative Land Impact Protocols--Camp Navajo was used as the primary test site for evaluation of various techniques for evaluation of human activity impacts on natural resources. The standard used was the Land Condition Trend Analysis (LCTA) developed by the U.S. Army Corps of Engineers. LCTA protocols were followed and the data generated from them were used as a baseline to compare other methods for assessing natural resources present on a property, and impacts on those resources. In addition to biologists, geologists, and geographers, statisticians and computer scientists were also involved in evaluating various methods for assessing natural resources and impacts. The LCTA method was found to miss a large percentage of flora and fauna on the site. This fact was probably caused by the relatively high threshold at which a particular vegetation type must be present in order to be represented among the LCTA plot allocations. For example, a unique vegetation type that makes up only 2% of the property will be excluded from the LCTA plot allocation. However, this same area might have many plant (and animal) species found nowhere else on the property. If this same site is highly impacted (possibly as a source of concealment), it might receive significant that would go unrecorded by the LCTA method. The concept of Special Use Plots, recently added to the LCTA protocol can help to solve this problem. At the same time, the TRIES analyses found that common vegetation types were over-represented in the sample. Far more plots (twice as many or more) were allocated to the most common vegetation type than were necessary to adequately (from a statistical standpoint) characterize that vegetation type. Resources in support of LCTA programs might better be used by decreasing the plot allocation to more common vegetation types while at the same time lowering thresholds for less common vegetation types to be included in the LCTA plot allocation. In light of the abundance of ground information gathered at Camp Navajo, this site was also the primary field testing area for the Enhanced Image Assessment System. Two M.A. theses were written from this work. Also see listing of reports and presentations. Publications based on this work are in preparation.

Environmental Cost Accounting --TRIES formed a team of accountants, economists, engineers, and regulatory experts to develop a methodology for identifying environmental costs associated with various activities. In cooperation with the Army's Production Base Modernization Activity (PBMA), the Environmental Cost Accounting (ECA) system was developed and tested on certain aspects of the SADARM weapons system. Site visits were made to production, testing, maintenance, storage, and demilitarization facilities to provide assessments of the life cycle costs for this weapon system currently under development. ECA was developed and tested, and taxonomies were created for classification of environmental costs. Reports and publications resulting from this work have been submitted to ARO. ECA was further developed using other funding, and through funding by the SERDP via the Office of Naval Research (ONR), TRIES further refined and modified ECA to produce a system of Environmental Activity Cost Analysis (EACA). EACA allows determination of environmentally related costs, and allows classification of those costs to various cost drivers. By providing a means for quantitative (as opposed to previously standard qualitative) estimates of environmental costs, EACA

complements the U.S. Environmental Protection Agency's (EPA) efforts to incorporate the concepts of Life Cycle Analysis into environmental management and planning. TRIES is exploring opportunities to implement EACA with private industries.

NitRem Demonstration--This project involved testing a technology (NitRem) developed at Battelle's Pacific Northwest Laboratory (PNL) to remove nitrogen pollutants (nitrates, nitrites, ammonia, amines, etc.) from aqueous waste streams. NitRem had been demonstrated at the bench scale, and a small scale operating system had been constructed. From a technical standpoint, NitRem was ready for large scale tests and commercialization. However, a number of regulatory, cultural, and economic hurdles stood in the way of progressing further. In order to secure permission for the large scale testing, a testing site was necessary. A testing site could not be secured without assurances to the test site that NitRem could solve their problem. It could not be shown that the problems of the test site (Radford Army Ammunition Plant) could be solved without testing of the test site waste stream. The test site did not have fresh waste because the waste-producing process had been halted due to environmental concerns that NitRem could address. This classic instance of a "Catch 22" was solved by bringing a surrogate waste from another facility, to the reactor at PNL. Tests on the surrogate waste were completed (report submitted to ARO). Funding for the large scale tests at Radford was secured from the U.S. Army's Industrial Operations Command (IOC). TRIES brought the expertise of chemists, engineers, regulatory experts, environmental cost accountants, sociologists, and others, to provide a solution to the problem. Through this project, the need for new approaches to technology transfer became apparent, and the TRIES Environmental Technology Development and Commercialization Center (ETDCC) was created. ETDCC is funded by private industry and the EPA.

Title V Air Permitting Methodology--A team of environmental engineers, regulatory experts, and chemists developed a broadly applicable methodology for determination of the need for, and process to obtain Clean Air Act Title V air permitting compliance for industrial facilities. The methodology was developed using the Longhorn and Lone Star Army Ammunition Plants as models for other plants. Although the methodology is specifically aimed at U.S. Army munitions production facilities, it is broadly applicable for many military and civilian industrial applications. Reports describing the methodology have been submitted to ARO.

CL-20/TNAZ Processing Optimization--Examination of the synthetic process for production of CL-20 and TNAZ was undertaken by a team of chemists, engineers, and environmental accountants, with the intent of enhancing the process by increasing yields, decreasing costs, and reducing hazardous waste production during manufacture. Theoretical options were derived for modification of synthesis. This effort was transitioned to SERDP funding through ONR for laboratory testing. Laboratory tests indicated that some of the proposed methods might be applicable for energetics manufacture. Since most of the processing steps are not unique to energetics manufacture, there are potential civilian applications of new methods.

TNT Alternative Manufacture Method--Use of solid support processes were investigated to maximize efficiency of nitration in TNT formation. Much of the pollution associated with TNT production is caused by nitration at suboptimal points on the toluene ring. Using solid supports, nitration can be directed to the proper points, thus considerably reducing pollutants. Solid state support chemistry was shown to function at the bench scale. Processes developed through this effort have potential for broad applications outside manufacture of energetics. Several publications on this work have been forwarded to ARO. Solid state synthesis methods are now being applied in combination with microwave, using State of Texas and SERDP funding (through ONR) to examine specific synthetic steps. Opportunities for technology transfer may be forthcoming from this work.

Integrated Natural Resource Management Plans (INRMP)--The INRMP was a new DoD initiative at the beginning of the TRIES project period with the ARO grant. The concept behind INRMP's was designed to be multi-disciplinary in nature, and to promote coordination with regard to natural resources among several groups on the military installations. Depending on the installation, these groups might include forestry programs, hunting and fishing programs,

agricultural leases (crops and/or grazing), ecotourism, military training, and other activities. While each of these groups were using and impacting natural resources on the installation and each had unique requirements, they quite often had completely different and separate reporting lines, some of these separated all the way to the DoD administrative structure in the Pentagon. Lateral communication among these groups was lacking on many installations. Development of an INRMP for the installation was a means to promote coordination among these various entities with impacts on natural resources of an installation, and to facilitate coordination of installation natural resource management with natural resource management of adjoining properties. Installations were aware that an INRMP would be required by a certain date in the future, but they had no experience or instruction on how an INRMP should be constructed. TRIES fielded multi-disciplinary teams including biologists, sociologists, political scientists, agronomists, foresters, wildlife managers, and former military personnel to write or assist in the writing of INRMP's for a number of installations. These installations included Fort Huachuca, Camp Robinson, Seymour Johnson Air Force Base, Dare County Bombing Range, Fort Fisher Recreation Area, Offutt Air Force Base, Whiteman Air Force Base, and Dixie Target Site. In addition, data provided by TRIES personnel were or will be incorporated into the INRMP's for Fort Polk, Dugway Proving Ground, Longhorn Army Ammunition Plant, Camp Gruber, Fort Crowder, Camp Bullis, Camp Navajo, Camp Clark, Wappapello Training Site, and Macon County Training Site. Several reports, presentation abstracts, papers, and a M.A. thesis were submitted to ARO as a result of these projects.

Wildfire Effects Study--A team of biologists, range scientists, and soil scientists was formed to assess effects of wildfires on soil erosion, vegetation, and bird populations in training areas on Fort Bliss. Although the project specifically addressed a need that Fort Bliss had for data relating to the effects of training-induced wildfires on the McGregor Range, results of the study are broadly applicable to other military installations, and to civilian lands in the same region. The project also provides a model for similar projects in other regions. Ten pairs of plots were selected. Within each pair, one plot was burned, one was not. Data were collected on the plots to determine differences between burned and unburned plots. These data measured effects on soils, vegetation, and bird use (breeding and otherwise). A parallel study by Texas Tech University, but not funded by TRIES, examined effects on insects, mammals, and reptiles. This project was the first field test for the USDA Soil Erosion Research Laboratory wind erosion soil collecting equipment under uncultivated field conditions. A copy of a M.A. thesis written as a result of this study was submitted to ARO.

Wetlands Delineation Methods Review--Depending on the definition of wetlands, and the criteria used to delimit wetlands, quite different interpretations are possible with regard to the amount of wetlands present on many properties. Areas of Camp Gruber, Fort Crowder, Camp Clark, Wappapello Training Site, and Macon County Training Site were inventoried for wetlands using criteria of the Army Corps of Engineers, EPA, and U.S. Fish & Wildlife Service. Reports on wetlands occurrences for each of these installations were provided to the installations according to the criteria specified by the installations. Additional study is being undertaken on the effects of the alternative procedures, and impacts that use of alternative procedures might have on management of properties. In addition, the fact that a previous wetlands delineation had been completed at the Macon County Training site, provided the opportunity to assess the repeatability of wetlands delineations.

Grassland Breeding Bird Survey--TRIES fielded a team of biologists and statisticians to develop and implement a method for sampling grassland breeding birds at the Pinyon Canyon Maneuver Site. While a number of standard methods exist for sampling breeding birds in forested areas, they do not produce satisfactory results when implemented in grasslands. In addition, the sampling protocol was required to assess the impacts of various levels of military training on the breeding birds. A system successful at assessing impacts of military training activities on grassland breeding birds could also be applied to assess impacts of other mobile human activities (motor bikes, 4-wheelers, snowmobiles, etc.) on grassland birds. The testing system was developed and tested at Pinyon Canyon. Technical reports resulting from this work have been submitted to ARO.

Biological Monitoring and Analysis Methods--Basic research was completed by a team of biologists, chemists, and remote sensing specialists to develop or enhance methods of monitoring effects of various human activities on animals. The methods combined field observations and experiments at Dugway Proving Ground with laboratory experiments and data collection at TRIES. Dugway was an appropriate field site since the analytical methods themselves could be tested on contaminants unique or nearly unique to Dugway, avoiding the necessity to sort out background contamination that might be found at other sites using other contaminants. Monitoring methods could also be conveniently tested at Dugway since the field personnel were already in place. Some additional telemetry work was done at Longhorn Army Ammunition Plant. Animals studied included raptors, canids, birds, pronghorn, and feral horses. Analytical methods developed involved examination of a variety of contaminants from a diversity of animal tissues. Monitoring methods included direct observation methods, methods to sample evidence of activity, radio telemetry, and trap sampling systems. Vegetation cover was also studied to assess its effects on animals' use and movement in various areas, and as a means for testing the Enhanced Image Assessment System (see above). New field and laboratory analytical methods have been developed (see list of presentations).

Fire Frequency Effects--Prescribed fire at various return intervals in longleaf pine systems at Fort Polk was studied for its effects on water quality, Neotropical migratory bird abundance, mammal populations, and stream fish communities. Results of this work can be applied on other Federal and non-Federal properties in the southeastern United States. A report summarizing this work has been submitted to ARO. Master's theses and presentations resulted from this work.

Natural Resources Management on Buffer Lands--Longhorn Army Ammunition Plant was used to study natural resources management programs on buffer lands at this Army Ammunition plant. Biologists, foresters, and sociologists participated in documentation of the natural resources present on the property, effects of management on those resources, and public perceptions of natural resources management of the property. The work included wetlands delineation, Neotropical migratory bird survey, mammal survey, and public perceptions survey. A report summarizing this work has been submitted to ARO. Master's theses resulted from this work.

Continuous Emissions Monitor--Physicists and engineers were teamed with regulatory experts to develop technology for a functional emissions monitor based on Particle Induced x-ray emissions. The system is aimed at producing cost effective real time emissions-monitoring capability. Initial feasibility studies and calculations were completed. The system was transitioned to State of Texas funding. This system has potential for future invention or technology transfer implications.

Phytoremediation of Shallow Groundwater--The use of trees to reduce spread of shallow groundwater pollutant plumes was assessed. Experimental work was initiated at Red River Army Depot, and data collection and analysis are continuing with funding in addition to the funding from ARO. If the method is successful, it may be used in a number of sites to decrease contamination of groundwater supplies.

Cultural Resources Management--Two projects were undertaken with regard to interdisciplinary cultural resource management. These were at Camp Navajo and Camp Bullis. While each was intended to provide integrated cultural resource programs along the lines of the Integrated Natural Resource Management Plans, neither of these projects went much beyond the data collection and documentation phase. While these projects provided interesting information, and should result in publications and/or presentations, neither provided extensive input as to multi-disciplinary approaches.

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- Ruffino, D.M. & M.L. Thies. (submitted). Species assemblages and habitat preferences of rodents on south Texas rangelands. Texas Academy of Science. Tyler, TX. Abstract in: Program and Abstracts of Papers, 101st Annual Meeting, 5-7 March.
- Rush, R.N. 1994. Global Positioning System. Presentation to Camp Gruber National Guard Training Site Staff, Baggs, OK.
- Rush, R.N. 1996. GIS and wetlands delineation at Camp Gruber National Guard Training Site. Presented to Texas Academy of Science, abstract published in Proceedings Texas Academy of Science, Texas A&M Galveston, Galveston, TX, 29 February-2 March.
- Rush, R.N. 1996. Use of GIS in environmental issues. Presentation to University of St. Thomas, Houston, TX, October.
- Sloan-Nelson, K.B., I.H. Perry, & R.N. Rush. 1996. GIS determination and jurisdictional wetlands delineation. Texas Academy of Science. Galveston, TX. Abstract #152 in: Program and Abstracts of Papers, 99th Annual Meeting, 29 February-2 March.
- Slough, S.W. 1994. Concrete learners in the abstract world of chemistry. 41st Annual Conference for the Advancement of Science Teaching, Beaumont, TX.
- Slough, S.W. 1994. Clarification of the constructivist's and traditionalist's views of learning science: Implications for reform. 41st Annual Conference for the Advancement of Science Teaching, Beaumont, TX.
- Slough, S.W. 1996. Area under constructivism: A pilot study using a World Wide Web home page to assess professional development. Presentation to National Association of Research in Science Teaching, St. Louis, MO, 31 March-1 April.
- Slough, S.W. 1997. Content, concepts and algorithms in high school chemistry. Texas Academy of Science. Huntsville, TX. Abstract #184 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.
- Slough, S.W. & R. McGrew-Zoubi. 1996. SamCATS: Teachers teaching teachers. 1996 Conference for the Advancement of Science Teaching, Austin, TX.
- Slough, S.W., S. Fleming, & E.L. Chiappetta. 1996. Conceptual chemistry: A high school chemistry curriculum development proposal. Presented to American Chemical Society 52nd Southwest Regional Meeting, abstract published in Proceedings of the American Chemical Society 52nd Southwest Regional Meeting, Houston, TX., 17-19 October.
- So, W. 1994. Preserving singular values and displacement rank. Presentation to First Southeastern Linear Algebra Conference, Chattanooga, TN, May.
- So, W. 1995. Isometrics of lp-norms. Presentation to American Mathematical Society-MAA joint meeting, San Francisco, CA, 15 January.
- Stephens, R.K., J.C. Turner, & T.E. Barber. 1996. Technique for the determination of carbamate pesticides in animal blood serum and tissue. Poster presented to American Chemical Society 52nd Southwest Regional Meeting, abstract #214 published in Proceedings of the American Chemical Society 52nd Southwest Regional Meeting, Houston, TX., 17 October.
- Stephens, R.K., J.C. Turner, & T.E. Barber. 1997. Determination of carbamate pesticides using solid phase extraction and high performance liquid chromatography with fluorescence detection. Texas Academy of Science. Huntsville, TX. Abstract #94P in: Program and Abstracts of Papers, 100th Annual Meeting, 7 March.
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- Taylor, D.C. & M.L. DeVore. 1997. Geospatial data standards for herbarium collections: Identification of data confidence levels using geographic information system (GIS) technology. Texas Academy of Science. Huntsville, TX. Abstract #52 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.
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- Van Fleet, P.J. 1995. Wavelets and remote sensing. Seminar Presentation, Eidgenossische Technische Hochschule, Zurich, Switzerland, 22 June.

- Van Fleet, P.J. 1995. Multiwavelets and properties of scaling vectors. Colloquium Presentation, Southern Illinois University, Carbondale, IL, 16 October.
- Van Fleet, P.J. 1995. Wavelets: A new splash in mathematics. Colloquium Presentation, Sigma Xi Lecture Series, Sam Houston State University, Huntsville, TX, 18 October.
- Van Fleet, P.J. 1996. Recurrence formulas for the moments of box splines and an application to wavelets. 102nd Annual Meeting of the American Mathematical Society, Orlando, FL, 10-13 January.
- Van Fleet, P.J. 1996. Enhancement of image assessment capabilities for natural resource characterization. Presented to SERDP Scientific Advisory Board Meeting, Arlington, VA, 15 August.
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- Van Fleet-Stalder, V., E. Becer, & T.G. Chasteen. 1997. Phototrophic bacteria and selenium, tellurium and antimony compounds. Texas Academy of Science. Huntsville, TX. Abstract #113 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.
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- Varma, R.S. 1997. Microwave-Assisted Reactions Under Solvent-Free 'Dry' Conditions. *First World Congress on Microwave Processing*, Session XIV: Chemistry IV-Solid State Synthesis and Theory. Paper No. XIV-3. Lake Buena Vista, FL, 5-9 January.
- Varma, R.S. 1997. Environmentally Benign Approaches to Organic Syntheses using Microwave Irradiation under Solventless Conditions. Engineering Foundation Conference on Clean Products and Processes, San Diego, CA, 2 June.
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- Varma, R.S. & R. Dahiya. 1997. A facile solid state oxidation of alcohols by clay-supported iron (III) nitrate (Clayfen) using microwave irradiation. Texas Academy of Science. Huntsville, TX. Abstract #102 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.
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- Varma, R.S., R.K. Saini, R. Dahiya, & H.M. Meshram. 1997. Solventless Oxidations with Supported Reagents using Microwaves: Novel Protocols for Organic Synthesis. pp. 154-157 of Proceedings of the 32nd Microwave Power Symposium, International Microwave Power Institute, Ottawa, Canada, 14-16 July.
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- Varma, R.S., S. Kumar, & R. Dahiya. 1997. Clay catalyzed solvent-free generation of enamines and nitroalkenes using microwaves: Applications in the synthesis of heterocyclic compounds. Texas Academy of Science. Huntsville, TX. Abstract #57 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.
- Warnock, M.J. 1993. Overview of the Texas Regional Institute for Environmental Studies. Presented to Office of Naval Research meeting, Huntsville, TX, 20 November.

- Warnock, M.J. 1994. Capabilities of the Texas Regional Institute for Environmental Studies. Presented to Department of the Army, National Military Fish and Wildlife Managers Association, Anchorage, AK, 27 March.
- Warnock, M.J. 1994. Overview of the Texas Regional Institute for Environmental Studies. Presented to Kiwanis Club, Huntsville, TX.
- Warnock, M.J. 1994. Overview of the Texas Regional Institute for Environmental Studies. Presented to Unitarian Fellowship, Huntsville, TX.
- Warnock, M.J. 1995. Capabilities of the Texas Regional Institute for Environmental Studies. Presented to Texas International Education Consortium, Austin, TX, February.
- Warnock, M.J. 1995. Summary of activities of the Texas Regional Institute for Environmental Studies. Presented to Department of the Army, National Military Fish and Wildlife Managers Association, Minneapolis, MN, 31 March.
- Warnock, M.J. 1996. Capabilities of the Texas Regional Institute for Environmental Studies. Presented to Science Advisory Board, Strategic Environmental Research and Development Program, Washington, DC, 15 August.
- Williams, H. 1996. The wetland identification and functional assessment of plant communities in Harrison Bayou, Texas. Wilderness and Natural Areas in Eastern North America: Research, Management, and Planning. Gatlinburg, TN, 19-23 May.
- Williams, H.M. 1996. The functional assessment of east Texas bottomland hardwood wetlands using the U.S. Army Corps of Engineers hydrogeomorphic assessment technique. Big Thicket Science Conference, Beaumont, TX, 10-13 October.
- Williams, H.M. 1996. The plant community identification and delineation of Harrison Bayou within the bounds of Longhorn Army Ammunition Plant, TX. Big Thicket Science Conference, Beaumont, TX, 10-13 October.
- Williams, H.M. 1997. The wetland identification and functional assessment of Harrison Bayou within Longhorn Army Ammunition Plant, TX. Presented to the U.S. Army and the Caddo Lake Institute. Longhorn Army Ammunition Plant, TX, 23 July.

List of Theses Written

- Autrey, B.C. 1997. Herpetofaunal assemblages of four vegetation types in the Caddo Lake area of northeast Texas. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Becer, E. 1997. Isolation and investigation of antimony-resistant bacterial cultures. M.S. thesis, Department of Chemistry, Sam Houston State University, Huntsville, TX.
- Cooper, J. 1997. A physicochemical and heavy metal analysis of eight streams flowing from Fort Polk, Louisiana into the Kisatchie National Forest. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Cooper, S.M. 1997. A determination of the effect of military activities on the water quality of four streams at Fort Polk, Louisiana, using benthic macroinvertebrate community structure as bio-indicators. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Creacy, G.P. 1996. Bird and small mammal habitat associations at Camp Navajo Army Depot, Arizona: Implications for management. M.A. thesis, Department of Biological Sciences, Sam Houston State University, Huntsville, TX.
- Daniel, R.S. 1997. Bird and small mammal communities of four forest types from the Caddo Lake area of northeast Texas. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Fischer, J. 1997. Population dynamics of small terrestrial mammals inhabiting eight habitat types on Fort Polk, Louisiana, M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Haynes, E. 1997. A study of attitudes and perceptions of residents in the Cypress Valley watershed and Caddo Lake areas. M.S. thesis, Dept. of Sociology, Stephen F. Austin State University, Nacogdoches, TX.
- Jones, D. 1996. Effects of range fire on habitat utilization by breeding birds in a northern Chihuahuan Desert scrubland. M.A. thesis, Department of Biological Sciences, Sam Houston State University, Huntsville, TX.
- Jones, L. 1997. Evaluation of the frequency of prescribed fire on the vegetative composition of an upland longleaf pine ecosystem. M.S. thesis, College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.
- Key, J.S. 1997. The hydrologic and biogeochemical functions of five East Texas bottomland hardwood wetlands using The U.S. Corps of Engineers Hydrogeomorphic Assessment Technique. M.S. thesis, College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.
- Laterza, K. 1997. Effects of prescribed burning frequency on avian communities in a longleaf pine ecosystem. M.S. thesis, College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.
- Matthews, J.S. 1997. Assessment of forest insects and diseases of Longhorn Army Ammunition Plant, Karnack, Texas. M.S. thesis, College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.
- McHugh, J.P. 1996. An evaluation of the U.S. Army's satellite imagery based site selection process. M.A. thesis, Department of Biological Sciences, Sam Houston State University, Huntsville, TX.
- Orth, K.E. 1996. A study of the benthic macroinvertebraic community structure of four streams located at Fort Polk in Vernon Parish, Louisiana. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Penland, W.D. 1996. A benthic macroinvertebrate study of four streams at Fort Polk, Louisiana. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Ruffino, D.M. 1997. Species assemblages and habitat preferences of rodents on south Texas rangelands. M.A. thesis, Department of Biological Sciences, Sam Houston State University, Huntsville, TX.
- Stevens, R. 1997. Fish communities inhabiting four streams traversing Ft. Polk, Louisiana. M.S. thesis, Dept. of Biology, Stephen F. Austin State University, Nacogdoches, TX.
- Tracy, B.D. 1997. The planning level plant community and wetland identification of Harrison Bayou within the bounds of Longhorn Army Ammunition Plant, Texas. M.S. thesis, College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.

List of Participating Scientific Personnel

Mr. Sean Allen	Mr. Bob Farmer
Ms. Linda Allison	Mr. Jason Fischer
Dr. Benny Arney	Dr. Robert R. Fleet
Dr. Tom Atchison	Mr. Jason Foster
Mr. Bradley C. Autrey	Dr. Michael S. Fountain
Dr. Karolis Bagdonas	Dr. Deborah Freile
Ms. Chloe Baldwin	Mr. Steven A. Frey
Dr. Tye E. Barber	Mr. Charles Gallion
Ms. Cynthia Bayes	Mr. Mumian Gao
Dr. R. Scott Beasley	Ms. Shelley Goodell
Mr. Dan Benefield	Ms. JoBeth Goodrum
Mr. Eser Becer	Dr. Lee Graham
Mr. Scott Bodie	Ms. Lakesha Green
Ms. Melinda Borel	Mr. Eric Griffith
Mr. Scott Bosworth	Mr. Matthew Groff
Ms. Bonnie Burgan	Mr. Hakan Gürleyük
Ms. April Burkett	Mr. Jeff Hall
Ms. Cheryl Button	Dr. Cecil Hallum
Ms. Terri Cabbell	Ms. Dana Harrison
Mr. Huadong Cao	Dr. Ennis Hawkins
Mr. Jiamin Cao	Mr. Eddie Haynes
Ms. Kathleen Carnes	Mr. Yuhua He
Dr. Mark Carpenter	Dr. Jamie L. Hebert
Dr. Johnny Carroll	Mr. David R. Hoffpauir
Dr. James L. Carter	Ms. Shen Huang
Dr. Thomas G. Chasteen	Mr. Phillip T. Hughes
Ms. Xiaodong Chen	Mr. David Hullum
Mr. Chad M. Cheshire	Mr. Jamie Humphreys
Mr. Andy Cloyd	Mr. Kindness Israel
Ms. Lesia Cobbs	Mr. Daniel Jones
Mr. Trey Cooke	Mr. Lance Jones
Mr. Jason Cooper	Ms. Charissa Kelly
Dr. Peter Cooper	Ms. Jennifer S. Key
Mr. Ronnie Cooper	Ms. Shazia Kirmani
Mr. Steve M. Cooper	Dr. Harry Konen
Dr. James E. Corbin	Ms. Jennifer Konen
Mr. Greg P. Creacy	Ms. Shelley Kremer
Ms. Gina Crick	Dr. David L. Kulhavy
Ms. Laurie Curra	Mr. Gaylon Lane
Mr. Ryan S. Daniel	Dr. Robert A. Lane
Mr. Gary Daniels	Ms. Helen Larabee
Dr. Ray Darville	Mr. Kenneth J. Laterza
Dr. Edwin S. Davis	Dr. Michael Legg
Ms. Kishmi Davis	Dr. Mark L. Leipnik
Mr. Chad Dean	Dr. Paul A. Loeffler
Mr. Kevin Dean	Ms. Gina Lundstrom
Mr. Gregory Desmond	Dr. Kenneth Lynch
Dr. Melanie L. DeVore	Mr. Yuan Ma
Mr. Terry Dillard	Mr. Mitch Maeda
Mr. Raymond Dolezel	Mr. Jonathan Marshall
Ms. Catherine T. Drumheller	Mr. James S. Matthews
Mr. Warren Duncan	Mr. Dennis A. McAfee
Mr. Michael Edinburgh	Dr. Jack B. McCullough
Mr. Kevin A. Estis	Dr. Darrell McDonald
Mr. Robert Eyeington	Mr. Kevin McGee
Ms. Victoria Faeo	Mr. John P. McHugh
Ms. Li Fan	Dr. Charles Meitzler

Ms. Julie Meyers
Mr. Steven Miers
Mr. Jeff Mihalik
Ms. Debbie Miller
Dr. Melinda Miller
Ms. Ting Ming
Mr. Paul Mitchell
Dr. Ralph R. Moldenhauer
Mr. Jason Lee Moore
Mr. Robert Musi
Dr. Guy L. Nesom
Ms. Meredith Oliver
Mr. Tom Oliverson, III
Ms. Kathleen E. Orth
Mr. Kevin Ostrand
Ms. Melissa Page
Ms. Lori Palmer
Dr. Richard H. Payne
Ms. Wendy D. Penland
Ms. Ann Pennell
Ms. Irene H. Perry
Mr. Briant Peterson
Dr. Edward C. Phillips
Mr. Matthew Phillips
Mr. Tom E. Pinney
Mr. Paul Plank
Mr. Barton Plant
Mr. Aaron Plocek
Ms. Jennifer Poncio
Ms. Ann Powell
Mr. Joe Presley
Ms. Paige Presley
Ms. Sarah Pylant
Dr. N. Ross Quarles
Mr. Huadong Qiu
Dr. Fred Rainwater
Mr. Joshua Reddoch
Dr. Walter V. Robertson
Mr. William G. Ross
Ms. Denise M. Ruffino
Mr. Richard N. Rush
Mr. Bradley Sargent
Ms. Sandra Selvia
Ms. Min Shen

Ms. Poonam S. Shrestha
Ms. Marilane Sioss
Ms. Kathleen B. Sloan-Nelson
Mr. Scott W. Slough
Dr. Wasin So
Mr. Jon Southard
Mr. Paul Sovelius
Ms. Keri Sowa
Dr. Jim Speer
Ms. Lisa Spencer
Ms. Kathie Springer
Ms. Leslie Stanford
Mr. Robert K. Stephens
Mr. Ronnie Stevens
Ms. Sarah Sullins
Mr. David C. Taylor
Ms. Kathleen Thies
Dr. Monte L. Thies
Mr. Mark Thomas
Ms. Angela Thompson
Mr. Kevin Thompson
Mr. Boyd D. Tracy
Dr. Jack C. Turner
Dr. Patrick J. Van Fleet
Dr. Verena Van Fleet-Stalder
Ms. Callie Vanderbilt-White
Dr. Rajender S. Varma
Mr. Michael Villa
Ms. Annette Walder
Dr. Michael J. Warnock
Ms. Felicia Washington
Mr. Bryan Weinzettle
Dr. Patrick J. White
Dr. Ricky C. White
Dr. Victor S. Whitehead
Ms. Alicia Whitley
Dr. R. Montague Whiting
Dr. Hans M. Williams
Mr. Chad Winkle
Mr. Jinghui Xie
Ms. Cari York
Ms. Linda Zientek

List of Personnel Earning Advanced Degrees and Degrees Earned

Master's Degrees:

Mr. Bradley C. Autrey	Master of Science in Biology	1997
Mr. Jason Cooper	Master of Science in Biology	1997
Mr. Steven M. Cooper	Master of Science in Biology	1997
Mr. Greg Creacy	Master of Arts in Biology	1996
Mr. Ryan S. Daniel	Master of Science in Biology	1997
Mr. Jason Fischer	Master of Science in Biology	1997
Mr. Eddie Hayes	Master of Science in Sociology	1997
Mr. Daniel Jones	Master of Arts in Biology	1996
Mr. Lance Jones	Master of Science in Forestry	1997
Ms. Jennifer S. Key	Master of Science in Forestry	1997
Mr. Kenneth Laterza	Master of Science in Forestry	1997
Mr. James S. Matthews	Master of Science in Forestry	1997
Mr. John McHugh	Master of Arts in Biology	1996
Ms. Katie E. Orth	Master of Science in Biology	1996
Ms. Wendy D. Penland	Master of Science in Biology	1996
Ms. Denise Ruffino	Master of Arts in Biology	1997
Mr. Ronnie Stevens	Master of Science in Biology	1997
Mr. Boyd D. Tracy	Master of Science in Forestry	1997

List of Honors, Awards, and Certifications Earned

Certifications in Wetlands Delineation:

Mr. Chad Cheshire
Mr. Robert Eyeington
Dr. Deborah Freile
Dr. Guy Nesom
Ms. Irene Perry
Dr. Edward Phillips
Mr. Richard Rush
Ms. Kathleen Sloan-Nelson

Certification for 24hr HAZWOPER Safety Training:

Dr. Melanie DeVore
Mr. Daniel Jones
Mr. John P. McHugh
Dr. Ralph Moldenhauer
Dr. Richard Payne
Ms. Kathleen Thies
Dr. Monte Thies
Dr. Jack Turner
Dr. Michael Warnock

Certification for 40hr HAZWOPER Safety Training:

Dr. Tye Barber
Mr. Chad Cheshire
Ms. Laurie Curra
Ms. Catherine Drumheller
Mr. Michael Edinburgh
Mr. Robert Eyeington
Mr. Hakan Gürleyük
Mr. Phillip Hughes
Ms. Lori Palmer
Ms. Melissa Page
Ms. Irene Perry
Mr. Barton Plant
Mr. Huadong Qiu
Mr. Joshua Reddoch
Mr. Richard Rush
Ms. Marilane Sioss
Mr. Robert Stephens
Mr. Michael Villa
Mr. Bryan Wienzettle

Wastewater Sampling and Field Analysis Training (Class C permits):

Mr. Chad Cheshire
Mr. Robert Stephens
Mr. Michael Villa

Other Honors/Awards:

- Burgan, B. 1997. Wavelet-based boundary detection. Texas Academy of Science. Huntsville, TX. Abstract #176 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March. Won award for best student paper at the annual meeting.
- Burgan, B. 1997. Wavelet-based boundary detection. Conference on Applied Mathematics 97. Oklahoma Central University, Oklahoma City, OK, 21-22 February. Won award for best undergraduate student paper at the conference.
- Hallum, C. Chair paper session. International Statistics Conference, SAS User's Group, Chicago, IL, 9-12 March 1996.
- Hallum, C. 1996. Keynote speaker at the meeting of the Houston Area Chapter of the American Statistical Association held at Rice University, Houston, TX, 14 May.
- Leipnik, M.R. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Article summarizing use of work on GIS for change modeling in watersheds. Research News section of New Waves, The Research Newsletter of the Texas Water Resources Institute, 9(3):6. October 1996.
- Quarles, N.R. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Article summarizing work with environmental cost accounting. The Military Engineer 89(583):34-35, February-March 1997.
- Quarles, N.R. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Invited participant and speaker at American Chemical Society Symposium on Emerging Technologies in Hazardous Waste Management, Pittsburgh, PA, 15-17 September 1997.
- Quarles, N.R. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Article summarizing work on Environmental Activity Cost Accounting. News Briefs section of New Waves, The Research Newsletter of the Texas Water Resources Institute, 10(2):10. August 1997.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). "Cancer Scientist at SHSU hopeful about Cancer Research," The Huntsville Item, Huntsville, TX, 22 September 1996.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). The Distinguished Alumni Award from the Kurukshetra University, Kurukshetra, India on the 40th Anniversary of the University, 1996.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). The 1996 Marjorie W. Margolin Prize for outstanding contribution to Retina Research by the Retina Research Foundation, Houston, 1996.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Feature Science/Technology article on research with microwave assisted chemistry-Molecular Magic with Microwaves. Chemical & Engineering News, pp 27-29, 10 February 1997.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). "Vying for Presidential Award: Professor's Research Focuses on Microwave Processing," The Huntsville Item, Huntsville, TX, 15 February 1997.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Served on US Environmental Protection Agency's Peer-Review Panel for award of Grants in Exploratory Research area on "Environmental Chemistry", Washington DC, April 1997.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). "Varma Presents Chemistry Research," The Huntsville Item, Huntsville, TX, 27 April 1997.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Invited speaker, EPA Green Chemistry and Engineering Conference, Washington, DC, June 1997.
- Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Invited conferee and session chair for Gordon Conference on Environmentally Benign Organic Synthesis, Queen's College, Oxford, England, August 1997.

Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Invited speaker and session chair for VI International Conference on Microwave and High Frequency Heating, Fermo, Italy, September 1997.

Varma, R.S. (Texas Regional Institute for Environmental Studies, Sam Houston State University). Invited speaker at International Conference on "Green Chemistry: Challenging Perspectives," Venice, Italy, September 1997.

Report of Inventions

None

Technology transfer

Several of the projects listed above have been transitioned to new funding sources. Each of these has technology transfer possibilities, but the technology transfer has not yet been completed. Many of the methods and techniques developed under the TRIES projects funded by ARO are widely applicable well beyond the military applications. Publications have come from these projects, and others are in the process of appearing. These publications will make the methods generally available for use.

The Enhanced Image Assessment System project led to funding from SERDP for further development of the system. Under the latter funding, intellectual property disclosure forms have been filed regarding components of the system.

EACA, which originated from ECA, in turn supported by ARO and the Army's PBMA, was further developed under funding from ONR, and is being considered by EPA as a standard method for determination of environmental costs of operations. Journal articles and presentations about EACA have generated considerable interest toward its implementation in private industry.

The NitRem Demonstration was part of an overall project primarily funded by the U.S. Army's IOC. As a result of the overall project, of which the ARO support was a part, the NitRem technology will probably be tested further and may have future commercial applications.

During the Fire Effects studies, use of the USDA wind erosion soil collecting equipment represented the first field test for this equipment under uncultivated field conditions. Use of this equipment was in cooperation with the USDA Soil Erosion Laboratory in Big Spring, TX.

The Title V Air Permitting Methodology developed by TRIES is being used by the Army's IOC to assess the need for permits, and obtain permits for air emissions. The method could also be used by private industry.

The Energetics Production Optimization projects led to additional funding by ONR for this work. Numerous papers were written on novel methods for chemical synthesis. Many of these syntheses have potential commercial applications, and have been described in journal articles.

New organics analytical methods were developed, and methods for remote monitoring of animal movements were enhanced during the projects on Biological Monitoring and Analysis. These advances have been published and/or presented, with article and abstract copies submitted to ARO.

The Continuous Emissions Monitor system may develop under independent funding to have commercial applications.

Phytoremediation of Shallow Groundwater experiments may yield a cost effective means of reducing contamination of some groundwater sources.